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US 5127463 A US 4874034 A

(58) Field of search

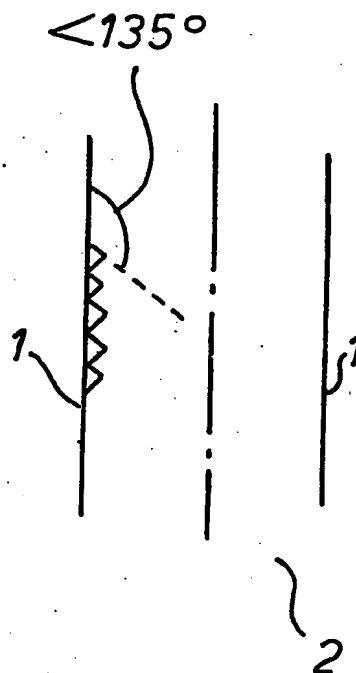
UK CL (Edition L) C5E EAQ

INT CL<sup>5</sup> C01B, F27D

(54) Regenerator-type reactor for production of hydrogen and/or carbon monoxide

(57) In a regenerator-type reactor for production from hydrocarbon-containing gases of gases essentially comprising hydrogen and/or carbon monoxide, with hydrocarbon cracking and/or water gas reaction steps, by alternating combinations of exothermic and endothermic reactions via solids arranged in the reactor, said solids are arranged in the form of checker work comprising refractory tubes and/or bricks, which are internally provided with or are arranged relative to one another to provide ledges or rims. The ledges or rims collect solid carbon produced as the result of cracking so preventing the carbon raining to the bottom of the reactor or being entrained with product gas.

FIG. 1



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FIG. 2

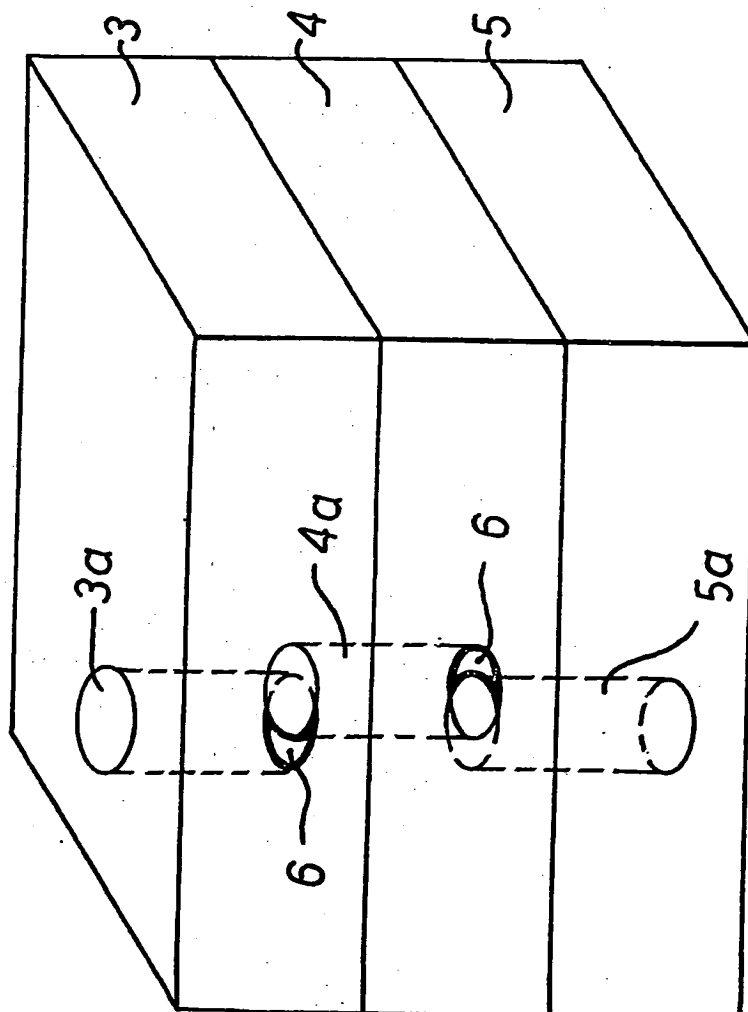


FIG. 1

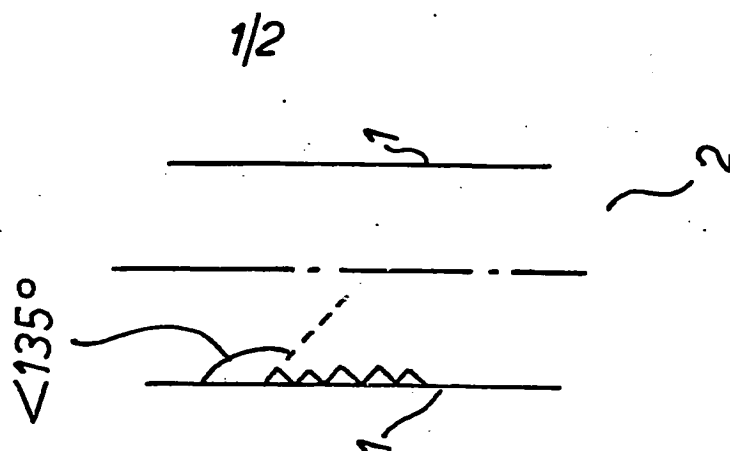
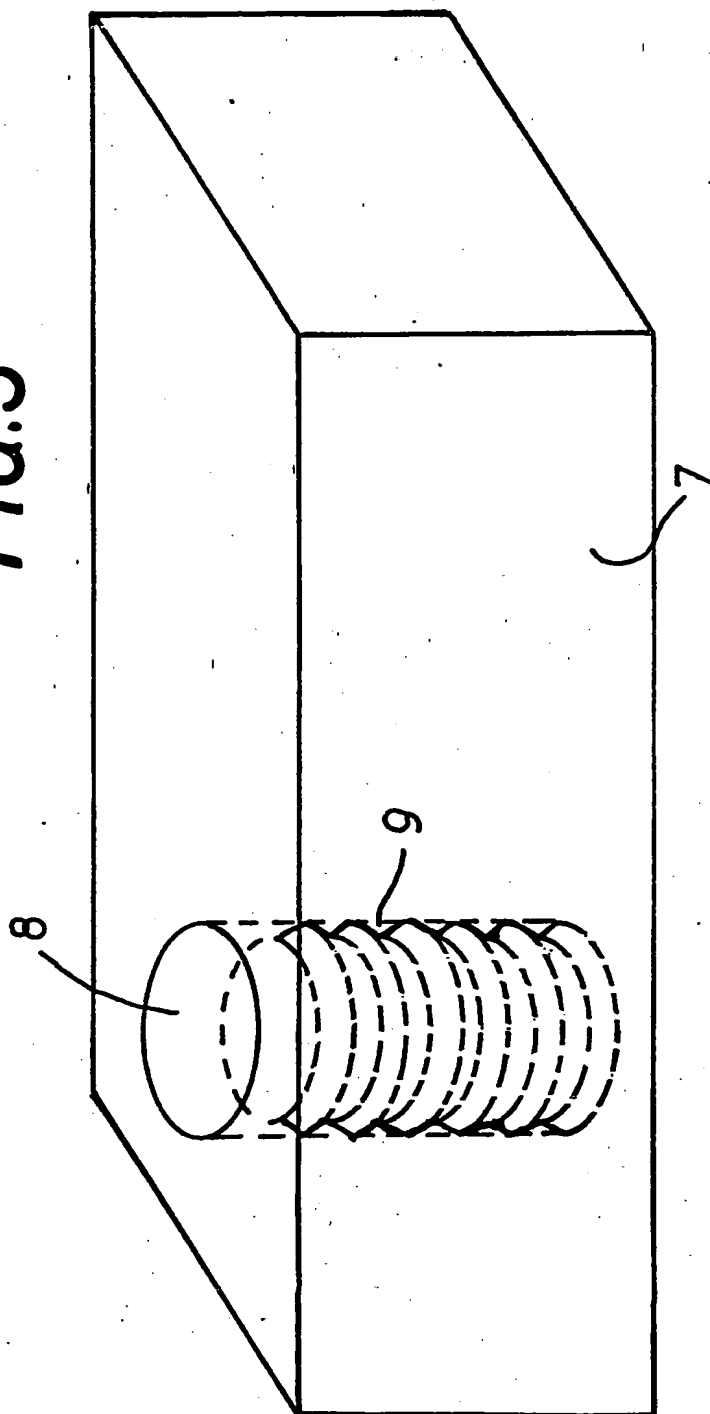


FIG. 3



# REGENERATOR-TYPE REACTOR FOR PRODUCTION OF A HYDROGEN-CONTAINING GAS

The present invention relates to a regenerator-type reactor for the production of hydrogen-containing gas or synthesis gas (which comprises in addition to hydrogen a substantial amount of carbon monoxide and usually small amounts of carbon dioxide, steam and/or unconverted hydrocarbons) from hydrocarbon-containing gases, with a hydrocarbon cracking step and/or a watergas reaction step, by alternating combinations of exothermic and endothermic reactions via solids in the reactor.

In regenerator-type reactors solids are suitably heated in a cyclic manner by means of suitable exothermic reactions and after each heating cycle suitable endothermic reactions such as cracking of hydrocarbon-containing gases (e.g. methane) are carried out to produce hydrogen and/or synthesis gas.

In case methane is used as feed gas the reaction  $\text{CH}_4 \longrightarrow \text{C} + 2\text{H}_2$  takes place, which after the addition of steam is followed by the reaction  $\text{C} + \text{H}_2\text{O} \longrightarrow \text{CO} + \text{H}_2$ .

Regenerator-type reactors are known to those skilled in the art and will not be described in detail. Normally they comprise an elongated vessel with a height of about 35-50 metres in which a cyclically heated bed of solids is present in the form of checker work. Such checker work suitably comprises refractory tubes and/or bricks.

Gas used for heating the checker work in a cyclic manner is combusted in a determined space of the reactor and the remainder of the (circular) cross-section of the vessel is filled with checker work.

When applying such reactors for carrying out the above process it is very desirable that deposited carbon can be "stored" otherwise the carbon will "rain" to the bottom of the (vertical)

vessel leading to plugging or it will be entrained with the product gas which may also lead to plugging or requiring a gas solid separation.

5 Thus, it is an object of the invention to provide a reactor of the above type for carrying out the above endothermic reactions for production of hydrogen-containing gas wherein the carbon can be "stored".

10 The invention, therefore, provides a regenerator-type reactor for production from hydrocarbon-containing gases of gases essentially comprising hydrogen and/or carbon monoxide, by hydrocarbon cracking and/or water gas reaction steps, by alternating combinations of exothermic and endothermic reactions via solids arranged in the reactor, said solids being constructed in the form of checker work comprising refractory tubes and/or  
15 bricks, characterized in that the refractory tubes and/or the bricks are internally provided with ledges or rims.

A ledge is herein defined as "narrow horizontal surface projecting from a wall".

20 The invention will now be described by way of example in more detail by reference to the accompanying drawings, in which fig. 1 represents a partial longitudinal section of a refractory tube vertically arranged in the reactor of the invention; fig. 2 represents a partial transparent view of a plurality of refractory bricks arranged in an advantageous embodiment of the reactor of the  
25 invention; and fig. 3 represents a partial transparent view of another refractory brick arranged in another advantageous embodiment of the reactor of the invention.

30 Referring now to fig. 1, when carrying out the process described in the foregoing, the carbon obtained from the above hydrocarbon cracking step is deposited on ledges or rims provided on the wall 1 of the vertical refractory tubes of the regenerator-type reactor. For reasons of clarity only one tube 2 is shown and the reactor as such is not shown as such reactors are known to those skilled in the art. Usually the tube diameter is about 1-4 cm  
35 and the number of tubes in a reactor is about 16,000.

The refractory tube may have a rough inner surface. Such an inner surface of the 1-4 cm diameter tubes can be defined as any surface with protuberances of 0.01-20 mm and an angle with the wall of the upper part of the protuberance of less than 135 degrees.

5        Fig. 2 represents a plurality of refractory bricks (3, 4, 5) arranged one above another in the reactor. For reasons of clarity the bricks have only been partially represented. Usually the bricks are hexagonally-shaped, each side of the hexagon being 30 cm. Each refractory brick (3, 4, 5) is provided with holes (3a, 4a, 5a,  
10        respectively) therein. Usually each hole has a diameter of 1-4 cm and the number of holes per brick is 10. For reasons of clarity only one hole per brick has been represented. In this embodiment a ledge or rim is created by installing the bricks with the holes in them in such a way that they are slightly staggered. The ledge will  
15        then be "moon" shaped and is represented by reference numeral 6.

      Fig. 3 represents a partially shown refractory brick 7 with a hole 8, wherein the brick is shaped in such a way that it has ledges 9 of 0.01-20 mm at the inner side of the hole. For reasons  
20        of clarity only one brick and only one hole in the brick has been shown.

      In these manners the ledges/rims act as a means for supporting the solid carbon resulting from the hydrocarbon cracking in regenerator-type reactors.

25        Various modifications of the present invention will become apparent to those skilled in the art from the foregoing description. Such modifications are intended to fall within the scope of the appended claims.

C L A I M S

1. A regenerator-type reactor for production from hydrocarbon-containing gases of gases essentially comprising hydrogen and/or carbon monoxide, with hydrocarbon cracking and/or water gas reaction steps, by alternating combinations of exothermic and  
5 endothermic reactions via solids arranged in the reactor, said solids being constructed in the form of checker work comprising refractory tubes and/or bricks, characterized in that the refractory tubes and/or the bricks are internally provided with ledges or rims.
- 10 2. The reactor as claimed in claim 1, characterized in that the inner surface of the refractory tubes is provided with protuberances, of 0.01-20 mm and having an angle with the wall of the upper part of the protuberance of less than 135 degrees.
3. The reactor as claimed in claim 1, characterized in that the  
15 refractory bricks are provided with a plurality of holes in them and are installed in such a way that they are slightly staggered and thus form a "moon" shaped ledge.
4. The reactor as claimed in claim 1, characterized in that the refractory bricks are provided with a plurality of holes in them,  
20 which are provided with ledges at their inner side.
5. The reactor as claimed in claim 1, characterized in that the ledges are in the range of 0.01-20 mm.

**Patents Act 1977**  
**Examiner's report to the Comptroller under**  
**Section 17 (The Search Report)**

-5-

Application number

GB 9305910.3

**Relevant Technical fields**

(i) UK CI (Edition L ) C5E (EAQ)

(ii) Int CI (Edition 5 ) C01B F27D

**Databases (see over)**

(i) UK Patent Office

(ii)

**Search Examiner**

R J WALKER

**Date of Search**

12 MAY 1993

Documents considered relevant following a search in respect of claims 1-5

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
E, X	US 5127463 A (HIRATA ET AL) See eg Figures 1-3	At least 1
X	US 4874034 A (HIRATA ET AL) See eg drawings	At least 1,2,4,5



Category	Identity of document and relevant passages	Relevant to claim(s)

#### Categories of documents

**X:** Document indicating lack of novelty or of inventive step.

**Y:** Document indicating lack of inventive step if combined with one or more other documents of the same category.

**A:** Document indicating technological background and/or state of the art.

**P:** Document published on or after the declared priority date but before the filing date of the present application.

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